PANEL DISCUSSION ON FUTURE NEEDS AND FUTURE DIRECTIONS

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Abstract

This is a brief summary of Session G, a panel discussion on Future Needs and Future Directions, at ECLOUD'04.

INTRODUCTION

The various talks at the ECLOUD'04 workshop have largely dealt with the status and progress to date on important aspects of electron cloud effects (ECE) that affect accelerator performance. Goals of the panel discussion were to complement the program of talks with a discussion that provides a broad overview of major issues for the future; develops a sense of the priority needs for experiments, theory and simulations; and outlines the future plans at the various laboratories to better understand electron cloud effects and mitigation of their adverse impacts on accelerator performance.

Ten panelists listed below, representing a broad spectrum of the community, started the discussion with short, 3-5 minute opening statements identifying the most important needs from their perspective and brief highlights of future plans for work on ECE at their respective institutions. Copies of the transparencies used in the opening statements are posted to the proceedings link at the workshop website [1].

Panel Members
John Seeman (SLAC),
Kazuhito Ohmi (KEK),
Hitoshi Fukuma (KEK),
Frank Zimmermann (CERN),
Jose Miguel Jiménez (CERN),
Roberto Cimino (LFN-INFN),
Giovanni Rumolo (GSI),
Andrei Shishlo for Stuart Henderson (SNS/ORNL),
Arthur Molvik (LLNL),
SY Zhang (BNL)

The panel discussion moderator was Robert Macek (LANL) and the session secretary Angelika Drees (BNL).

GENERAL THEMES

The opening remarks and ensuing discussions covered a mix of project specific needs and more general issues for the future. Panelists correctly tended to focus on the specific needs of the projects at their home institution. However, a number of more general themes did emerge including:

- Need for greater understanding of the important surface science issues at a more fundamental level,
- Systematic benchmarking of simulation and modeling codes against one another and against experiments,
- Self-consistent combined treatment of electron-cloud build up and beam dynamics,
- International collaborations on ECE,
- Methods to measure electron cloud density at the beam locations,
- Continued development of methods to suppress electron cloud formation – efficient beam scrubbing scenarios, NEG coatings, grooved surfaces, clearing electrodes, solenoids in quads, etc,
- Impact of shorter bunch spacing and higher bunch intensity on ECI for the next generation of high intensity machines,
- Characterization of gas desorption by heavy ion collisions with vacuum chamber walls.

Surface Science

There was general consensus that the surface science underlying secondary emission and gas desorption from technical surfaces is very important to this field but is not well understood at a fundamental level by the accelerator community. Treatment of the topic by accelerator scientists is largely phenomenological and focused on the characterization of secondary emission yields or gas desorption rates as functions of variables that can be readily measured or controlled by accelerator builders or operators. Efforts to enlist surface scientists for this workshop did not locate an expert outside of the accelerator field. Fortunately, two surface effects experts (Robert Kirby and Roberto Cimino) from within the accelerator community were able to attend and talk about their work. In addition, there is much valuable work carried out by our community largely by vacuum groups at the larger accelerator labs and was reported in Session C at this workshop. Roberto Cimino noted that the surface science issue requires a synergistic collaboration between theorists and experimentalists of several disciplines – accelerator, vacuum and surface scientists - working together to achieve the desired level of understanding. This goal may be too ambitious for a single laboratory since it requires significant resources. A coordinated collaborative effort amongst the various laboratories could be productive. It would require clearly articulated consensus support by the accelerator community.

Benchmarking of Codes

The need for systematic benchmarking of the various simulation codes has been noted and advocated by a number of speakers at this workshop and was again emphasized by Frank Zimmermann in the panel discussion. A coordinated effort amongst various laboratories is clearly desirable and about the only

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efficient way benchmarking can be carried out since the various code experts and developers reside at the different laboratories and the experimental results that can be used for benchmarking are obtained at different laboratories. Frank outlined coordinated efforts at benchmarking underway in Europe within the 6th Framework Programme of the European Union and included in the Coordinated Accelerator Research In Europe (CARE) activities, specifically, the N2 and N4 proposals. In addition, Frank discussed an abstract for a joint paper on code comparisons submitted to EPAC'2004. It was suggested that the International ATF collaboration could also address electron cloud benchmarking (and other) issues.

Self-consistent Models

To reduce the computing complexity, many simulation efforts to date have dealt separately with the electron cloud buildup and instability dynamics by using separate codes for each aspect. The instability threshold is then obtained for a given electron cloud density. In reality, the cloud is also influenced by the instability or coherent motion of the beam. The need for a self-consistent, combined treatment of the electron cloud buildup and the instability dynamics was identified as an important simulation issue for future high intensity machines by three panelists, Frank Zimmermann, Andrei Shislo (standing in for Stuart Henderson), and Art Molvik as well as by several speakers at the workshop. Art Molvik discussed Ron Cohen's roadmap for a self-consistent model of electron effects via self-consistent electron physics modules for the WARP code. The combined problem is a challenge to present-day computing power but is being tackled by a number of approaches. Various approximations and simplifications have been invoked, the trick being to reduce the computing time without losing essential physics.

International Collaborations on ECE

The benefits of pooling resources (expertise or experimental facilities) in collaborative efforts to solve problems of common interest are well-recognized by the accelerator community. Recommendations for regional and international collaborations on various aspects of ECE came up several times in workshop and during the panel discussion e.g., in regard to benchmarking codes and developing a fundamental understanding of the surface science underpinning secondary emission and gas desorption. The CARE program was mentioned by Frank Zimmermann as a European effort to parallel the US-LARP program which was established to coordinate and streamline R&D work for LHC at BNL, LBNL and FNAL in the US. Frank also outlined proposed experiments at other labs to address concerns for LHC and CLIC projects at CERN. The Heavy Ion Fusion Virtual National Laboratory, represented by Art Molvik on the panel, is a collaboration between LBNL, LLNL and PPPL to address development of heavy ion drivers and related topics. Electron effects and gas desorption are among the issues that they are researching. In fact, it can be said that national and international collaborations (HIF-VNL, SNS, VLHC, etc) are becoming the norm for the development of major new accelerator facilities.

Electron Cloud Density at the Beam Location

The importance of measuring the electron cloud density at the beam location was discussed by John Seeman and Hitoshi Fukuma. This is the quantity of fundamental interest (for understanding ECI) not the electron flux striking the wall or the pressure rise which are the more commonly observed indicators of electron clouds. The electron density at the beam is not easily measured. Development of a suitable diagnostic to measure the electron density at the beam is a challenge for experimentalists. One such effort using microwave transmission measurements (reported at this workshop by Tom Kroyer) gave unexpected results that are not yet resolved. A diagnostic that gets closer to the desired quantity for long bunch proton beams is the electron sweeping diagnostic which was developed at PSR to measure the electrons remaining in the pipe in the beam free region between bunch passages. It still requires an assumption that the electrons surviving the gap are very low energy and some calculations to translate this number to the electron density at the beam.

Suppression of Electron Cloud Buildup

Several panelists, Fukuma, Jiménez, and Zhang, identified evaluation of NEG coatings as an important need. It offers the promise of a low SEY that is stable under varying gas loads. For RHIC there is the need to also evaluate its effectiveness in reducing ion and electron desorption of gases (pressure rise). The question of its long term effectiveness and the need for reactivation require evaluation. Miguel Jiménez notes the uncertainty of extrapolating SPS results with NEG coatings to LHC where seeding with photoelectrons may change the NEG behavior.

Other methods to suppress electron cloud buildup were frequently cited as important needs for the future. John Seeman identified tests of grooved surfaces as a priority item for SLAC. Miguel Jiménez discussed development of efficient beam scrubbing scenarios for SPS and LHC. Hitoshi Fukuma listed R&D needs at KEKB regarding several measures for reducing or removing electrons including coatings, antechambers and methods applicable to quadrupoles (clearing electrodes, solenoids and permanent magnets). Frank Zimmermann identified evaluation of the efficiency and side-effects of coatings, clearing electrodes, and antechambers among his list of hot topics for CLIC.

Impact of Shorter Bunch Spacing

The need to determine the effect of shorter bunch spacing and/or higher bunch intensity proposed for new or upgraded facilities was discussed by John Seeman (for new e^+,e^- colliders), Frank Zimmerman (for CLIC) and SY Zhang (for RHIC). Frank showed an interesting plot of observed electron cloud thresholds vs. bunch spacing with a plausible extrapolation to shorter spacing. Reliable simulations for shorter bunch spacing are needed for the new machines which points again to the need for sound benchmarking of codes against measurements at existing machines.

Gas Desorption

Gas desorption (and electron emission to a lesser extent) by beam collisions with the vacuum chamber walls is a major concern for the heavy ion machines such as RHIC, present and future machines at GSI and drivers for heavy ion fusion. The measurement of gas desorption by heavy ions was mentioned by SY Zhang as an important item for understanding the pressure rise issues at RHIC. Elucidating the mechanism for gas desorption by heavy ions colliding with the wall was identified by Art Molvik as a priority need for the heavy ion fusion program. Giovanni Rumolo identified measurement of gas desorption by heavy ions as a priority for the GSI program. At GSI there is great interest in more studies on the dependence of the desorption yield on parameters such as the projectile energy, angle, charge state and mass, and on the target material. To have a clear picture of the desorption processes seems indispensable to ensure a successful operation of the future machines as well as of the present GSI machines when upgraded as injectors for the new rings.

PROJECT-SPECIFIC ISSUES

In the next few paragraphs I will report on more project specific issues addressed in the panel discussion i.e., ones which were not mentioned in the previous discussion of general themes.

SLAC

Possible future projects being studied at SLAC were identified by John Seeman to include a luminosity upgrade for PEP-II, a Super B Factory with 476 MHz RF, and an Advanced B Factory with 952 MHz RF. Priority items for future ECI work include 1) simulations for e^+ bunch trains with ~6000 bunches with short, 1 ns bunch spacing and 100 ns gaps and 1.5×10^{11} e^+ per bunch, 2) measurements of electron cloud density along the e^+ bunch path, and 3) measurements of the improvements obtained using “grooved surfaces”.

Super KEKB

Kazuhito Ohmi and Hitoshi Fukuma identified Super KEKB as major new project at KEK that would need to deal with ECE. Super KEKB involves a charge switch scenario where the HER would be an 8 GeV positron ring and the LER a 3.5 GeV electron ring. The HER would be subject to ECI seeded by photoelectrons from synchrotron radiation while the LER could be subject to beam-ion instabilities. Understanding of the two-stream effects in each of these rings, but particularly the ECE for the 8 GeV HER, is needed to justify the switch. Other priority needs for the existing KEKB project have already been mentioned in the earlier discussion of general themes.

LHC and CLIC

CERN activities for the future focus on LHC and CLIC. Most of the priority needs for CLIC were mentioned in the earlier discussion of general themes. Frank Zimmerman also lists trapping of electrons in wiggler fields as another hot topic for CLIC. The program to deal with ECE at LHC is extensive and the various needs were identified in the opening remarks by Frank Zimmermann and Miguel Jiménez. The issue of long-time survival of electrons which includes the effect of elastic reflection at low energy and trapping in magnetic fields (especially quadrupoles) needs more work. Electron trapping in quadrupoles is also deemed a crucial issue at PSR. Reliable prediction of long-term emittance growth for LHC was identified by Frank as the most important simulation need. The simulations should include lattice variations around the ring, self-consistent combined treatment of electron cloud buildup and response of the cloud to any beam instability, adequate boundary conditions, and, possibly, space charge, impedances, beam-beam interactions, feedback and chromaticity. The code needs to be benchmarked with suitable experiments (e.g. at SPS).

SNS

ECE have been considered a serious technical risk for the SNS project and many mitigating features are built into the SNS ring design as was discussed by Andrei Shishlo (standing in for Stuart Henderson). Priority work for future will be in two areas: 1) accurate prediction of instability thresholds and modeling of coupled e-p dynamics; 2) evaluation and testing of active feedback to damp the e-p instability in long-bunch proton machines. Work is underway to study ECE using the ORBIT code which now contains electron cloud physics including buildup and its coupling with proton beam dynamics. Near term goals are to benchmark against PSR observations and to explore possibilities for reducing trailing-edge multipactor by tailoring the longitudinal profile of the beam. A collaborative effort is underway to explore the possibility of testing e-p feedback at PSR.

GSI

Electron clouds are not expected to form at the present and future GSI machines with the possible exception of coasting beams for which it is still an open issue, according to Giovanni Rumulo. The simulations by Kuzuhito Ohmi have shown that perturbed coasting beams can interact with electrons coming from ion losses and cause multipacting. A self-consistent simulation tool, which could be reliably applied to the coasting beam case, is presently under development and some (preliminary) results will be hopefully presented in EPAC. Giovanni also mentioned a possible experiment at GSI (first proposed by he and Frank Zimmermann at ECLOUD’02) to try to excite a controlled electron cloud instability by means of a "detuned" electron cooler in rings equipped with an e-cooler, such the SIS or the ESR. The aim of this kind of measurement would simply be to gain a deeper insight into the e-cloud instability mechanism and possibly discover some of its parametric dependences.

RHIC

SY Zhang outlined the priority issues for the future operations at RHIC. The pressure rise problem is a multifaceted issue for RHIC involving both electron multipacting and ion-induced gas desorption depending upon the particular operating conditions. Understanding the role of ion-induced desorption is a priority. Evaluation of NEG coatings with respect to its ability to reduce ion-induced and electron-induced desorption is another important task. With 360 bunches in RHIC, electron multipacting is expected and implies possible beam instability and emittance growth problems. If it occurs in cold regions it could mean a possible heat load problem. The question of electron clouds in the cold regions of RHIC is of great interest to CERN in view of its implications for LHC commissioning.

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REFERENCES

[1] http://icfa-ecloud04.web.cern.ch/icfa-ecloud04/agenda.html